Appendix B Case Studies

(Note: All information in this appendix was provided by the vendor, Rocky Mountain Remediation Services (RMRS). Inclusion of any information is at the discretion of RMRS, and does not necessarily constitute U.S. Environmental Protection Agency concurrence or endorsement.)

The following are case studies of sites using Envirobond™ to successfully stabilize lead, arsenic, cadmium, and other RCRA metals. The examples cited include remediation of a brownfield type of site, a former battery recycling site, and sludge from a waste water treatment site, which are typical of the types of sites where Envirobond™ has been deployed.

B1. *In situ* Treatment of Mining Waste at Former Mining Site

The effectiveness of the Envirobond™ process with mining waste and mill tailings has been superb. In addition to meeting the EPA standards for TCLP, the results of the TCLP testing have typically met the more stringent UTS. Figure 4 shows the results from a mining site in Central City, Colorado. At this site, arsenic, lead, and zinc were the contaminants of concern, exceeding the EPA's threshold level. Untreated soil was given the TCLP test, and lead and zinc exceeded the standards without treatment. Arsenic was present at 4 ppm, which is just below the RCRA standard. After treatment with Envirobond™, all three metals were below the UTS standards. The primary objective of the project was to stabilize the waste to levels that would meet the Environmental Protection Agency's (EPA) criteria for releasing the site for development. Equipment included a front-end loader, a road grader, a tractor-tiller, spreading equipment, a water truck, and a sheep's foot field compactor.

This project demonstrated the versatility of Envirobond™. Less than 4 wt. %, Envirobond™ and fly ash were added to the volume of soil, and it was mixed using field equipment. The treated soil was used to form a base for future construction. The soil was successfully layered, mixed and compacted to meet the proctor specifications for construction. The project also demonstrated that it is easy to pre-

Figure 4. On-site Full Scale *In situ* Treatment of Mine Tailings in Central City

	Arsenic	Lead	Zinc	Mercury
Total Metals (ppm)	136	1270	1270	5.9
TCLP Extract Before Treatment (ppm)	0.07	91.7	108	<0.02
TCLP Extract After Treatment (ppm)				
Sample 1	<0.05	<0.05	1.5	
Sample 2	<0.05	<0.05	1.0	
Sample 3	<0.05	<0.05	3.9	
Sample 4	<0.05	<0.05	4.5	
Sample 5	<0.05	<0.05	4.2	
Sample 6	<0.05	<0.05	4.7	
Sample 7	<0.05	<0.05	3.3	
Average	<0.05	<0.05	3.3	
TCLP Regulation CFR 261.24 (a)	5	5	NA	0.2
Current Univerisal Treatment Standard (UTS)	5	0.37	5.3	0.2

pare Envirobond™ for use in field applications. Finally, Envirobond™ does not add bulk to the waste, which is especially important when the waste is transported to a disposal facility.

Two alternatives were evaluated for remediating the site. The first was to excavate the waste piles, and other contaminated areas, and transport them to a disposal site in Denver, Colorado. There are two serious disadvantages to this alternative. The cost of transportation and disposal is high, and after the waste leaves the site, the owner remains liable for any further contamination that may occur during transportation, or at the burial site for years to come.

The second alternative was on-site treatment. The major disadvantage to this alternative was that the use of traditional cement, lime, or other similar additives will add large amounts of material to the waste, and some of these treatments are ineffective on some types of metals. Some metals such as zinc cannot be treated without adding large volumes of additives. With cement or lime, the heavy metals may not leach out, but they are still available to future environmental upsets because they are not permanently bound to the chemical additives. For these reasons, even at a higher cost, the EPA was inclined to allow only the excavation and removal of the soil.

The second alternative is much more attractive with a binder that does not add weight or volume. Use of the Envirobond™ binding agent adds less than 2 wt. % to the volume, and when combined with compaction, significantly reduces the volume. Furthermore, Envirobond™ chemically binds the metals so that they are not only physically stabilized, but they are incorporated with a chelating bond that cannot be penetrated even under severe conditions. It is not soluble, and the treated soil hardens to form a cap over the treatment area.

Costs are reduced when compared to cementation or excavation and hauling. With cementation, the additional bulking of the waste can easily add a 100% volume increase. The cost of materials handling and mixing is also higher. With excavation and hauling, there are additional transportation and disposal costs, and the excavated material would have to be replaced with clean fill dirt. All of these factors add cost that is avoided with Envirobond™.

B2. Treatment of Metals-contaminated Sludge

The Envirobond™ product can also be used to treat contaminated sludge from water treatment plants, evaporation ponds, waste treatment plants, and mining and milling operations. Typical contaminants in sludge include cadmium, lead, chromium, arsenic, aluminum, zinc, and barium. The treatment plant in this case study treats water from a mining district where the primary metals of concern are cadmium, zinc, and manganese. If the treated sludge exceeds 1 ppm cadmium, it must be shipped to a hazardous waste disposal site. The other metals are not a factor in shipping, but it is desirable to reduce them as low as possible.

The plant produces between 800 and 1400 cubic yards of 40 wt. % sludge per year. The plant uses a typical co-precipitation process that generates the sludge. In addition to the co-precipitation process, the plant treats the sludge to stabilize the cadmium to a level that will meet the RCRA TCLP standard for land disposal. (Less than 1 ppm cadmium.) Envirobond™ was successfully used to treat this sludge. The flow sheet for the process estimates the weight % of the cadmium, zinc, and manganese to be 0.017 wt.%, 1.9 wt. % and 3.64 wt. % respectively. Envirobond™ has treated the cadmium in the sludge to below 1 ppm TCLP. Significant reductions were also seen in the zinc and manganese. (To 16 ppm TCLP manganese and 255 ppm TCLP zinc). It is estimated that the cost to treat the sludge with Envirobond™ is about one-half the cost of traditional treatment.

B3. Treatment of Battery Recycle and Disposal Sites

Envirobond™ has been tested for use on two former battery sites, and is currently in use at one. In both cases, the levels of lead are similar to the high levels seen in the SITE demonstration. Those levels are often more than 90,000 ppm total, and as much as 1200 ppm after extraction using the TCLP test.

There are many sites where spent lead-acid batteries were reprocessed to recover metals. The batteries were typically cut open and sulfuric acid was allowed to drain into holding ponds. Soil contaminated by these ponds was saturated with the lead-containing acid, which accounts for the high levels present. The battery casings were then discarded and lead was recovered and smelted into ingots for reuse in the battery industry. Typical contamination around battery sites includes surface, groundwater, and soil that are contaminated with acid and extremely high concentrations of heavy metals such as lead, cadmium, and arsenic. The lead is typically very leachable due to the high acid content of the soil.

Treatment of these soils with Envirobond reduces the leachability of the lead and other metals found in contaminated soil at battery sites to the RCRA TCLP standards. The following table shows the treatability results and actual site results for a typical battery site. For this project, the soil was transported to a mixing area of about 1000 sq. ft. Approximately 1000 ton batches were mixed. The contaminated soil was layered in two layers with Envirobond reagents in the middle. Mixing was accomplished with a backhoe. The results show that excellent results were obtained, with all batches achieving the RCRA Standard of 5 ppm after TCLP testing. Figure 5 shows the results from this site.

Figure 5. Battery Recycle and Disposal Site Results

Contaminant	Total Lead (ppm)	Pretreatment TCLP (ppm)	Envirobond Treated TCLP (ppm)	RCRA Standard (ppm)
Lead (Treatability Result)	47800	956	1.97	5
Lead (Treatability Result)	74800	1160	1.47	5
Field Results (1000 ton batches)	47000	956	3.7	5
1000 tons	to 95000	to 1160	3.96	5
1000 tons			2.07	5
1000 tons			1.54	5
1000 tons			0.13	5